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ABSTRACT

To determine whether poor readers employ less efficient strategies in processing logical connectives than do good readers, 34 ninth grade students participated in a study. Half of the students were good readers and half were poor readers. An acquisition list consisting of 18 target sentences and 6 fillers was constructed. A list of 42 recognition sentences was also developed. Of these, 18 were the original target sentences and 3 were original fillers; the remaining sentences were modifications of the acquisition list. The students listened to the taped target sentences and then completed a distractor task. Following this, they heard the second list of sentences and were asked to indicate on an answer sheet whether they had heard the same sentence in the first exercise. Results suggest that both good and poor readers attend selectively to features of sentences containing logical connectives when asked to remember them. While poor readers do not appear to attend to the general sense of sentences as well as do good readers, they seem to attend equally well to the underlying logical relationships. (FL)

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ADOLESCENTS' UNDERSTANDING OF LOGICAL CONNECTIVES IN A SENTENCE MEMORY TASK[1]

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ADOLESCENTS' UNDERSTANDING OF LOGICAL CONNECTIVES IN A SENTENCE MEMORY TASK[1]

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Logical (or linguistic) connectives (words such as if-then, and, or) clearly play an important role in signalling to the reader/listener the logical propositional relationships that underlie these surface structures (e.g. conditionality signalled by if-then; conjunction by and; etc), and there has been considerable attention paid to children's understanding and use of them. (For a review of this research, see Walmsley, 1977).

Two general approaches have been taken in these investigations of children's understanding of logical connectives. One, represented by Neimark & Slotnick (1970), Paris (1973) and Beilin & Lust (1975), has emphasized the importance of connectives as they relate to children's understanding of the logical propositional relations themselves. In other words, these researchers have been more interested in children's understanding of the underlying relations than they are in their understanding and use of the surface structures that mark them. A second approach, represented by Gardner (1975), Robertson (1968) and Mahoney & Domaracki (1977) has focused on children's understanding of connectives as they relate to relations in naturally-occurring reading materials. Here the interest has been to determine whether children know the appropriate

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logical connective to match particular contexts in which logical relations are expressed. One distinct advantage of this approach is that it taps children's understanding of those logical relations that frequently occur in materials to be encountered typically in school.

Much has been learned from studies following these approaches--the former has shown, for example, that children's understanding of logical connectives are closely related to their understanding of truth-functional logical processes such as intersection, union and complementation (Beilin & Lust, 1975), and that this understanding is still developing during adolescence (Neimark & Slotnick, 1970). The latter has provided some much needed evidence of the frequency of certain connectives in reading materials (Robertson, 1968), and in special subject areas such as science (Gardner, 1975).

The contribution of these approaches to a better understanding of how readers and listeners gain access to underlying relations expressed by these connectives leaves much to be desired, however. For example, the first approach appears to ignore the fact that readers rarely need to tap into the highly abstract logical propositions of, say, exclusive disjunction. It may well be that a full understanding of these propositional relationships is a function of being at what Piaget terms "formal operations", and not only are less than half the adolescent population at this stage but also it may be considered not a necessary prerequisite for adequate comprehension of most reading materials (cf Neimark, 1975). The second approach, while based on naturally-occurring text and naturally-occurring logical relationships, uses a paradigm (i.e. sentence completion, fill-in-the-blank) that describes whether a child knows or recognizes appropriate connectives in particular contexts, but allows little inference to a description of the use actually made of such connectives while listening or reading. Further, while it has been shown that the performances of good and poor readers (reading ability being defined as a score on a standardized reading test)

may be differentiated on these tasks, the question of whether different strategies are employed by good and poor readers in processing logical connectives remains wide open.

The present study used a sentence memory task as a means of gaining access to some of the strategies used by readers, both good and poor, in processing logical connectives. Sentence memory task paradigms have been successfully employed by Bransford, Barclay & Franks (1972) in promoting a constructivist view of text processing, and have similarly been employed by several researchers in reading (cf Ohnmacht & Fleming, 1975). The paradigm consists of presenting Ss with a list of sentences (acquisition), then, after an interval, presenting a second list (recognition) and asking Ss whether they heard these recognition sentences during acquisition. Some of the sentences presented for recognition have been modified, and Ss' recognition of such modifications or their failure to recognize them are viewed as evidence of their having employed one strategy or another to represent acquisition sentences in memory.

For the present study, the sentence memory paradigm was used to investigate aspects of sentences containing logical connectives attended to by reader/listeners. For example, if the reader attends primarily to surface characteristics, then we would expect him to notice if we substituted one connective for another without changing its or the sentence's meaning (e.g. substituting when for if in the sentence "Cars get better mileage figures if they are less heavy"), or if we changed the order of clauses (e.g. "Cars get better mileage figures if they are less heavy" for "If they are less heavy, cars get better mileage figures"). If a reader attends primarily to the general semantic intent of the sentence, then we would expect him not to notice surface modifications, but to be aware of modifications made to the general sense of the sentence (either by changing a single, but important word, or by distorting a whole phrase) even though the logical relationship underlying this

general sense has been undisturbed (e.g. "If chemicals build up on the underside of a car, rust will soon appear" for "If road salt...." ; "If you see a car on the roadside with its hood raised, you know its driver has been caught speeding" for "If you see a car on the roadside with its hood raised, you know there's been a breakdown"). Next, if a reader attends primarily to the underlying logical operation, then we might expect him to ignore surface modifications of the connective and perhaps semantic intent modifications but notice a change in or omission of the underlying relations (e.g. "Most people drive at less than 55 mph, thus saving both lives and gasoline" for "If everyone drove at less than 55 mph, we would save both lives and gasoline"). Finally, if we modified both the semantic intent and the logical relationships, we might expect readers to notice such a gross distortion with greater ease than either modifications of the semantic intent or the logical operations singly (e.g. "The carburetor's function is to mix gasoline and air in the engine" for "If too much air is mixed with gasoline in the carburetor, the engine runs lean").

Although we have little a priori evidence of differences between good and poor readers in this regard, we might nevertheless expect that poor readers might employ less efficient strategies than good readers (cf Gibson & Levin, 1975) and rely more heavily on the surface characteristics, be less able to detect modifications in logical operations, and so on. Our evidence (e.g. Mahoney & Domaracki, 1977) is that they do not perform as well--it is yet an assumption that they process differently, as opposed to merely slower.

METHOD

Subjects

The subjects were 34 ninth grade students, 17 relatively good readers and 17 relatively poor readers, selected randomly within reading group from an entire ninth grade population in a junior high school in the suburbs of Albany, New York. Good

readers were identified as scoring at or above the 60th percentile on a standardized reading achievement test (Metropolitan Reading Achievement Test). Poor readers were identified as scoring at or below the 40th percentile. The mean percentile scores of good readers was 76.9 (mean grade equivalent=9.9); and of poor readers, 27.9 (mean grade equivalent=6.8). Of the good readers, 5 were male, 12 female; of the poor readers, 12 were male, 5 female.

Materials

Materials consisted of 18 target sentences, drawn equally from three subject areas (cars, plants, animals), and 6 fillers. Target sentences contained the logical propositional relationship of conditionality, expressed by the surface structure if; filler sentences did not. These 24 sentences comprised the acquisition list.

In addition, 42 recognition sentences were constructed. Of these, 18 were the original 18 target sentences; 3 were the original fillers. The remaining sentences (N=21) were modifications of the acquisition list. Six such modifications were made:

1. Surface modifications

   (a) connective only. "If a tree receives an abundance of water, it will grow rapidly" changed to "When a tree receives an abundance of water, it will grow rapidly".

   (b) order of clauses. "If a baby gorilla is raised by people, it begins to act like a human baby" changed to "A baby gorilla begins to act like a human baby, if it is raised by people".

2. Semantic modifications

   (a) specific word. "If grass is deprived of sunlight, it will wither" changed to "If a plant is deprived of sunlight, it will wither".

   (b) general sense. "If a wild animal is kept in a cage, its behavior changes" changed to "If a wild animal is kept in a cage, it will try to escape".

3. Logical relationship modifications

> "If there is a heavy rain when fruit trees are in bloom, there will be little fruit on the trees that year" changed to "There was a heavy rain and the fruit trees had little fruit".

4. Semantic and Logical relationship modifications

> "If a baby lion is raised in captivity, it loses the ability to survive in the wild" changed to "Baby lions sometimes lose their ability to survive in the wild".

In the surface modifications, both the general sense and the logical relationships are left undisturbed. In the semantic modifications, the logical relationships are left intact, but either a specific word or the general sense have been distorted. In the logical relationship modifications, the general sense has been left relatively intact, but the conditionality has been dropped. In the final category. semantic and logical relationship modifications, the general sense and the conditionality have been distorted and omitted respectively.

Filler sentences were only modified by changing the general sense (i.e. "People tend to blame the government when there is widespread unemployment and high taxes" changed to "People tend to blame the government when they have to pay higher prices in the supermarkets").

Each modification type was represented in one sentence from each subject area (i.e. cars, plants, animals), thus creating three opportunities to make judgements on the same modification type.

Sentences were randomly assigned, within acquisition and recognition lists, with the exception of the first and last sentence of the recognition list being a filler. A tape-recording was made of both lists (using a male, standard English voice), leaving exactly five seconds between sentences in both lists. Instructions were also taped, alerting Ss to the task at the beginning of the acquisition list, and giving instructions for completing the protocols (as well as a practice item) at the beginning of the

recognition list.

PROCEDURE

Acquisition. Ss were tested in groups of 1 to 5 in a quiet, distraction-free room. The stimulus tape was played on a cassette recorder, Ss listening through headphones connected to a listening station (a standard volume and tone setting was used for all Ss). Ss were told to listen carefully to a group of sentences in order to answer questions about them later on. The 24 target sentences were then read, with 5 sec intervals between each.

Ss were then asked to complete a 2-minute distractor task, involving systematic marking of particular letters in a paragraph. Procedural matters (practice items, gathering protocols, etc) added 3 minutes to this task: thus, Ss had 5 minutes between acquisition and recognition lists.

Recognition. After the interval, Ss were told that they would hear more sentences, but this time they were to mark on an answer sheet whether they heard the exact same sentence before the break, and to indicate their degree of confidence in their judgement. Two judgements therefore were indicated--a YES/NO (I heard/did not hear the exact same sentence before), and a five point scale, from VERY UNSURE to VERY SURE (about whether I heard the exact same sentence before). Ss were also told that some sentences might be read more than once (although none actually were).

RESULTS

Ss' responses were recoded to give a 10-point rating scale, from +5 (meaning a high degree of confidence that a subject heard the sentence before) to -5 (meaning a high degree of confidence that a subject did not hear the sentence before).

Mean recognition ratings of the two groups (good and poor readers) were computed

for the six sentence modification types (surface, semantic, logical, semantic & logical modifications, with subcategories within surface and semantic). In addition, mean recognition ratings were computed for sentences not modified (both targets and fillers), and for sentences (modified and unmodified) by subject area. These findings are presented in Table 1.

Insert Table 1 about here

A two-factor analysis of variance was performed to compute the significance of differences between good and poor readers and between sentence modification types. The ANOVA table is presented in Table 2. As can be seen, main effects and sentence modification type are highly significant ($p. < .001$), and differences between good and poor readers is significant ($p. < .043$).

Insert Table 2 about here

Post-hoc comparisons of differences in sentence modification type (using Tukey's A procedure--see Kirk, 1968) reveals that the two surface modifications (connective, clause order) are significantly different from the others ($p. < .05$), but not from each other. Beyond that, the differences are not so clear-cut. Semantic modifications of specific words are not significantly different from modifications in the general sense, or from modifications in meaning and logical relationships combined, but they are significantly different from modifications in logical relationships only ($p. < .05$). Semantic modifications in the general sense are not significantly different from modifications in logical relationships. There are no significant differences between

similarly modified target and filler sentences.

DISCUSSION

It would appear from this experiment that both good and poor readers do attend selectively to features of sentences containing logical connectives when asked to remember them. That they tend to ignore surface characteristics that do not distort either the general semantic intent or the specific underlying logical propositional relationship of conditionality, and instead attend more carefully to semantic and logical features is not altogether surprising, given the growing body of research supporting a constructivist view of sentence memory (cf Barclay, 1973). In fact, the greater the distortion of the general meaning of the sentence, the more confidently Ss judged a distortion had indeed been made. Thus surface characteristic modifications were least noticed, specific word modifications next to least, and general sense and logical relationship modifications most noticed (these groups were statistically significant, $p. < .05$). As a group, however, Ss did not make too fine a distinction between modifications that distorted the general sense, the logical relationships, or both combined. If anything, the combined distortion of logical relationship and general sense was less readily rejected by subjects (which may be an indication that sentences representing these categories were not rigorously enough distinguished).

When analyzed by reading group, however, a different picture emerges. Although the differences between good and poor readers was found statistically significant ($p. < .05$), they were not sufficiently dissimilar to confirm the general expectation of a marked difference in performance. Some reasons for this are suggested later. But an inspection of Table 1 reveals that poor readers do have a somewhat different pattern of responses. For example, while they exhibit roughly the same indifference

to surface modifications (although they appear to notice the connective change more than good readers, and with somewhat less variation), they markedly differ in their judgments on distortions of the general sense (in both targets and fillers), showing a consistent pattern of paying less attention to the general sense than good readers. They pay equal attention, however, to the distortions in the underlying logical relationship (conditionality), and clearly pay more attention to this feature (and with less variation) than they do to general sense features. Their recognition of target sentences not modified is almost identical to good readers, and while they are not as aware as good readers of filler modifications (further evidence that they do not pay as close attention to the general sense as good readers), the variation is equal to that of good readers.

There are some important limitations in this study that emphasize the exploratory nature of its findings. Firstly, the sentence memory paradigm used in this study was a listening, not a reading task. This might explain why differences between good and poor readers barely made it to statistical significance; the same procedure using visual stimuli will probably reveal greater differences. Secondly, it may be that the grade level chosen for this study and the criteria for determining reading ability were too high and too loose respectively. Although there are clear differences between the good and poor reader groups in terms of measured reading ability, it cannot be said that the poor readers are poor in the absolute sense (they have a mean grade equivalent reading score of 6.8): perhaps differences at lower grade levels will be found more applicable and have a greater bearing on the results, particularly in the matter of test score variation.

Thirdly, we are aware that the task demands make a significant difference in

determining a subject's strategies and maybe will result in different features being attended to than the ones attended to in this study (cf. Barclay, 1973; Ohnmacht & Fleming, 1975): the instructions in this study were deliberately general (following Bransford & Franks, 1972) and we expect that various orienting conditions may yield different results that emphasize the context-bound nature of feature attention.

Despite these limitations, what this exploratory study suggests is that poorer readers in the ninth grade do, contrary to expectations, attend to similar features as better readers: although they do not appear to attend as well as better readers to the general sense of sentences, they seem to attend equally to the underlying logical relationship (conditionality). We expect that as we extend these investigations across grades, other logical relationships (e.g. conjunction, disjunction), modes of presentation (e.g. visual), and orienting conditions, we will make distinctions between good and poor readers more explicit. This study seems to show that it will be worthwhile to make these extensions.

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TABLE 1
Mean recognition ratings of subjects by sentence modification type

Sentence Modification Type			Good Readers (N=17)	Poor Readers (N=17)	Total (N=34)
SURFACE MODIFICATIONS	a. connective	mean	2.94	3.18	3.06
		s.d	(2.39)	(1.85)	(2.12)
	b. clause order		2.84	2.59	2.72
			(2.60)	(2.30)	(2.45)
SEMANTIC MODIFICATIONS	a. specific word		-1.90	-1.31	-1.61
			(2.78)	(2.45)	(2.60)
	b. general sense (targets)		-3.48	-2.41	-2.94
			(1.76)	(1.77)	(1.82)
	c. general sense (fillers)		-4.18	-2.99	-3.58
			(1.56)	(2.19)	(1.97)
LOGICAL RELATIONSHIP MODIFICATIONS			-3.53	-3.55	-3.54
			(1.76)	(1.52)	(1.62)
SEMANTIC & LOGICAL RELATIONSHIP MODS			-2.53	-1.38	-1.95
			(2.08)	(2.73)	(2.46)
UNMODIFIED SENTENCES	a. Targets		3.10	3.24	3.17
			(1.33)	(1.14)	(1.22)
	b. Fillers		2.33	1.06	1.70
			(2.29)	(2.65)	(2.52)
BY SUBJECT: 1. CARS	a. modified		-1.60	-0.89	-1.25
	b. unmodified		2.96	3.56	3.26
2 PLANTS	a. modified		-0.98	0.12	0.05
	b. unmodified		2.84	3.01	2.93
3 ANIMALS	a. modified		-1.22	-0.66	-0.94
	b. unmodifed		3.51	3.16	3.33

Note: Figures in parentheses are standard deviations; others are means

TABLE 2

2 x 7 Analysis of Variance: Score by reading group, sentence modification type

Source of Variation	Sum of Squares	DF	Mean Square	F	Significance of F
Main Effects	1661.875	7	237.411	50.408	.001***
Reading Group	19.053	1	19.053	4.045	.043*
Sentence Modification Type	1642.822	6	273.804	58.136	.001***
2-way Interactions (R, ST)	17.986	6	2.998	.636	.999
Residual	1054.982	224	4.710		